IMPROVING ELEVATOR QUALITY THROUGH MAINTENANCE

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ABSTRACT

The improved quality and performance of newly manufactured elevators has heightened the expectations of building owners and users of older model elevators. Maintenance companies are responding to this need by improving the quality of existing installations. This paper describes methods of improvement through enhancement maintenance.

1. TYPES OF MAINTENANCE WORK

Maintenance for elevators usually covers two types of work: preventive maintenance and corrective maintenance.

1.1 Preventive Maintenance

Preventive maintenance is performed according to maintenance contract specifications and includes inspection, replacement of worn parts, and adjustment.

1.2 Corrective Maintenance

Typical corrective maintenance involves the repair of failures. The objective of corrective maintenance is to restore an elevator to normal operating condition.

Both types of maintenance attempt to maintain or restore the elevator to the level of quality it possessed when originally installed. This paper discusses another type of maintenance that takes a further step to upgrade quality and performance beyond the original conditions. We call this enhancement maintenance.

1.3 Enhancement Maintenance

Based on information accumulated through corrective and preventive maintenance, enhancement maintenance aims to improve elevator performance to fully satisfy customer quality expectations and represents the ideal control conditions for the maintenance company.

2. WHAT IS ELEVATOR QUALITY?

We used the following indicators to evaluate the quality of an elevator.

2.1 Quality Indicators

- Call back service rate

  - Entrapment failure rate
  - Frequent failure rate
- Repair time
- Fatal failures
- User injuries

2.2 Performance Indicators

- Acceleration (including vibration) and noise level during operation
- Smoothness and noise level of sliding doors
- Performance of group control operations

Note that customer complaints are another valuable measure of reliability and performance.

The ease of checking the conditions of an elevator with trouble can also be considered equipment quality indicators. (The easier the check, the shorter the repair time.)

2.3 Description of Quality Indicators

This section describes some of the quality indicators.

2.3.1 Call back service rate

In simple terms, each time an elevator customer requests the maintenance company to correct an abnormality is counted as one service call.

The call back service rate is defined as:

$$\text{Call back service rate} = \frac{\text{number of service calls per month}}{\text{number of contracted elevators per given month}}$$

The call back service rate is calculated by group (model, elevator use, building use, and others), so we ordinarily use it as an index of quality for each group.This grouping enables us to make effective improvements to elevators, because we can easily identify objects of improvement.

2.3.2 Repair time

This is the amount of time required to complete the repair work from start to finish. Mean repair time is used as statistical data.

2.3.3 Fatal failures

The following are considered fatal failures:

- Failures that might cause physical injury to users
- Failures that seriously inconvenience the customer (including system shutdown, lengthy delay)

2.3.4 Frequent failures

We employ our own extraction standard for elevators with exceptionally unsatisfactory MTBF (mean time between failure) records.

3. ENHANCEMENT STRATEGY

3.1 Procedures for Initiating Enhancement

This section outlines the steps taken before initiating enhancement work.

(a) Identify the quality problem based on accumulated information.
(b) Determine whether the problem actually requires enhancement. If it does, determine the enhancement method and objective.
(c) Prepare necessary parts and manuals for maintenance personnel, then issue enhancement work orders to field staff.

3.2 Acquisition of Quality Information

Information on the quality indicators listed in Section 2.3 is needed to evaluate the quality of an elevator.

The following describes our system to acquire this information.

(Figure 1 shows the information flow of data aquisition.)

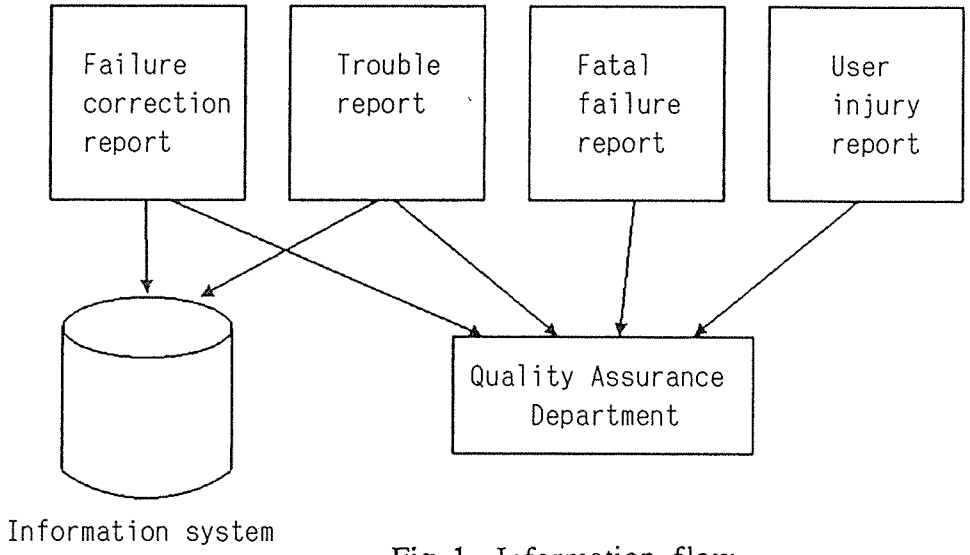

Fig. 1 Information flow

3.2.1 Failure correction report

A failure correction report is submitted to the customer each time corrective measures have been taken. We also process the data in the reports on our computer system. The information items shown in Figure 2 are typically coded for this purpose.

Date of failure, building number, car number, maintenance call time, staff arrival time, repair completion time, location of problem, disposition, cause of failure, condition of failure...

Fig. 2 Typical failure correction data

3.2.2 Trouble report

The trouble report informs the elevator manufacturer of defective equipment and the current status of deposition. The report is issued upon customer and user requests or whenever a defect in any of following categories is found during periodic maintenance inspections:

- Defects in equipment, parts, functions, quality, or performance
- Suspected design or manufacture defects with unknown cause
- Defect obstructing maintenance access

Like the failure correction report, the trouble report contains the same data listed in Figure 2 and is also processed by our computers.

3.2.3 Fatal failure report

If a fatal failure occurs, the branch office in charge reports the failure and its deposition to the main office and the manufacturer of the equipment.

3.2.4 User injury report

If an elevator user is injured, the branch office in charge reports the accident and its deposition to the main office and the manufacturer of the equipment.

3.2.5 Information system

Information on facilities (including elevators, escalators, and air conditioners) under our control can be accessed from terminals anywhere the information is stored. Quality indicators on file are coded data from the failure correction reports and trouble reports.

Sometimes trouble with a particular machine or model is found before it causes a failure. In this case, the details are described in a trouble report. This information is very valuable. As a maintenance company with many elevators under contract, we can collect special information such as performance variations in machines of the same model.

3.3 Identifying Quality Problems

Problems with elevator quality can be identified by classifying quality information, examining the actual situation and determining maintenance weak points.
Figure 3 shows the information flow for identifying quality problems.

3.3.1 Information processing with computers

The amount of data inevitably requires the use of computers. Figures 4 and 5 show some examples of how we analyze failure information from the field. The examples show what failures occurred, how often and which parts were involved.

3.3.2 Identifying problems through reports

Computer analysis provides only a quantitative view of problem data. Failure reports must be examined in a different way to interpret the implications of the data regarding potential fatal problems. For this purpose, other forms for reporting quality problems are used along with the trouble report. Since these other reports also deal with problems of maintenance quality, product quality problems must be extracted from them.

3.3.3 Relationship between information system data and report contents

Section 2 described the indicators we use to analyze quality. In practice, after analyzing data from the information system, we verify in individual reports the details on failures resulting from a specific problem. Sometimes the procedure is reversed. After a problem has been discovered in individual reports, the frequency of the problem is checked with information system data.

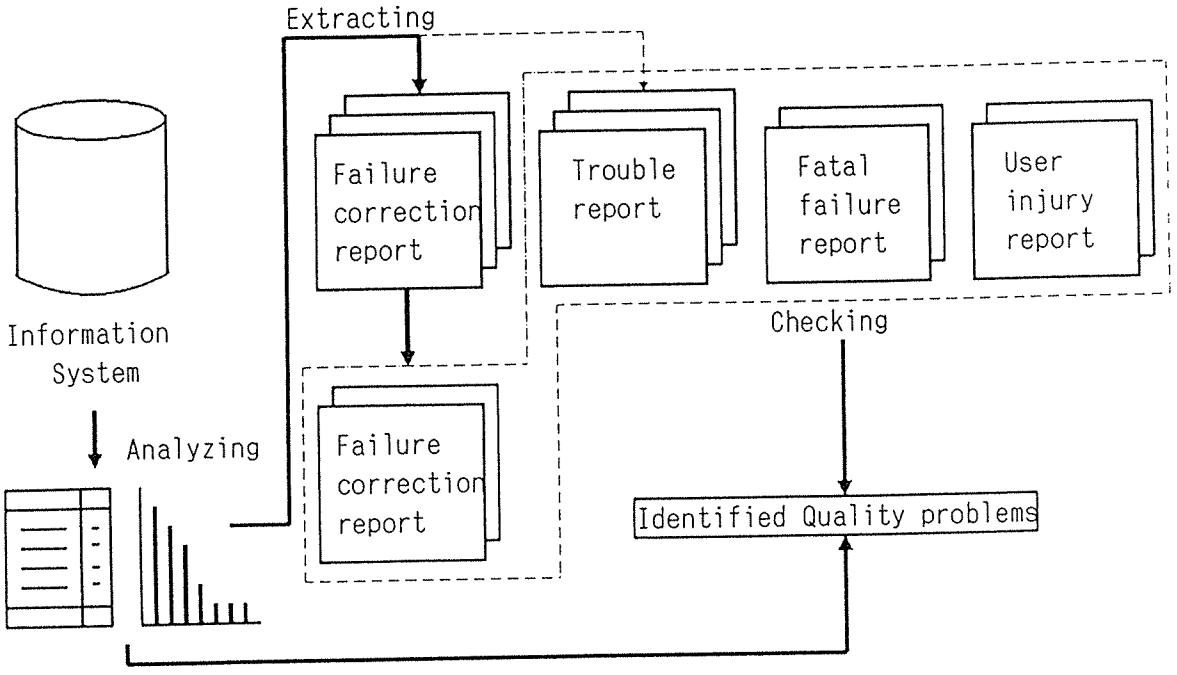

Fig. 3 Information flow for identifying quality problems.

ACEE-1 Model Analysis

Part	No. of Failures
Car door	70
KR-type relay	53
S-type relay	41
Floor sill	40
V-type resistor tube	37
Car sill	33
Fuse	29
:	:
:	:
:	:
Total	:

Fig. 4 Equipment failures by part

Part	Cause	No. of Failures
Car door	Carelessness (object caught in doors)	45
	Improper operation (door opening)	9
	Improper riding (object caught in doors)	6
	Improper operation (object caught in doors)	4
	:	:
	:	:
	:	:

Fig. 5 Car door failures by cause

3.4 Enhancement Work Responsibility

Once it is determined that quality enhancement is required, the next question is who will do the work; the maintenance company or the manufacturer of the facility.

If the problem is related to reliability, the contractor is often determined by the type of elevator. Usually the maintenance company does the work for older model elevators if there is no design problem. The manufacturer customarily takes the responsibility for newer models currently in production.

If the same failure occurs frequently due to incorrect operation by the customer, the elevator is not considered problem-free and enhancement work may also be performed in such cases.

3.5 Quality Enhancement Method

After deciding the items to be improved, the procedure is then determined. Even in cases where the maintenance company determines all the details, we ask for final approval of the manufacturer before beginning any work.

Enhancement work usually encompasses modification, replacement, or adjustment of the equipment.

3.6 Notification of Quality Enhancement Method

After an enhancement method has been determined, it must be submitted to the maintenance field staff. We use the forms shown in Figure 6 to issue the work order.

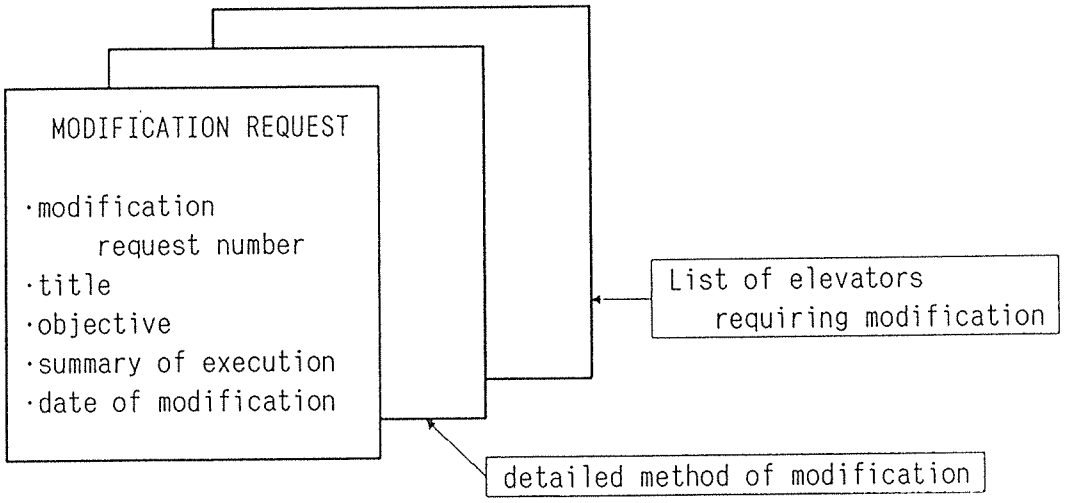

Fig. 6 Modification request

3.7 Execution of Quality Enhancement

In general, the modification request do not explicitly specify which workers will perform the modification or adjustment. These documents provide clear descriptions of the work procedure and operating instructions so that any maintenance personnel can accomplish the task.

For enhancement work the progress of the work is monitored and controlled by computer.

3.8 Examples of Quality Enhancement

The following sections describe examples of actual enhancement work.

3.8.1 Addition of selector shear auto correction circuit

An auto correction circuit was added if the mechanical selector is not aligned with the car position.

3.8.2 Maintenance computer interface

We currently use pocket computers in our maintenance work. Since these computers were inapplicable to older model elevators, we solved this problem by installing computer interfaces inside the old elevators.

3.8.3 Interface upgrade

Interfaces that used relays suffered frequent malfunctions as relays aged. These interfaces were replaced by solid-state devices.

3.8.4 Elimination of stop shock

Creep speed pattern resistors were replaced to widen the adjustment range of creep speed. This eliminated the shock to the car when stopping.

4. CONCLUSION

This paper has described the processes used by our maintenance company or the elevator manufacturer to enhance the equipment based upon information collected through maintenance work.

We wish to emphasize that we are committed to continuing our ceaseless efforts to achieve the highest level of quality, not only to the extent of our maintenance contracts, but at any time that user needs and our policy demand. We also proud that our ongoing efforts have contributed much to quality enhancements in the design of new elevators.

In this paper, I referred to the outline of the procedures in activities for quality enhancement. As for the details, I will explain them in the presentation, exemplifying some concrete cases.

5. AUTHOR BIOGRAPHICAL DETAILS

Yasushi Takeuchi joined Mitsubishi Electric Building Techno-Service Co., Ltd. in 1977 upon graduating from the Engineering Department of Meiji University. After five years as an elevator maintenance field technician, he moved to his current position where he is involved in quality assurance for high-speed elevators. He has recently participated in the development of high-speed VVVF (variable voltage variable frequency) elevators at the Inazawa Works of Mitsubishi Electric Corporation.